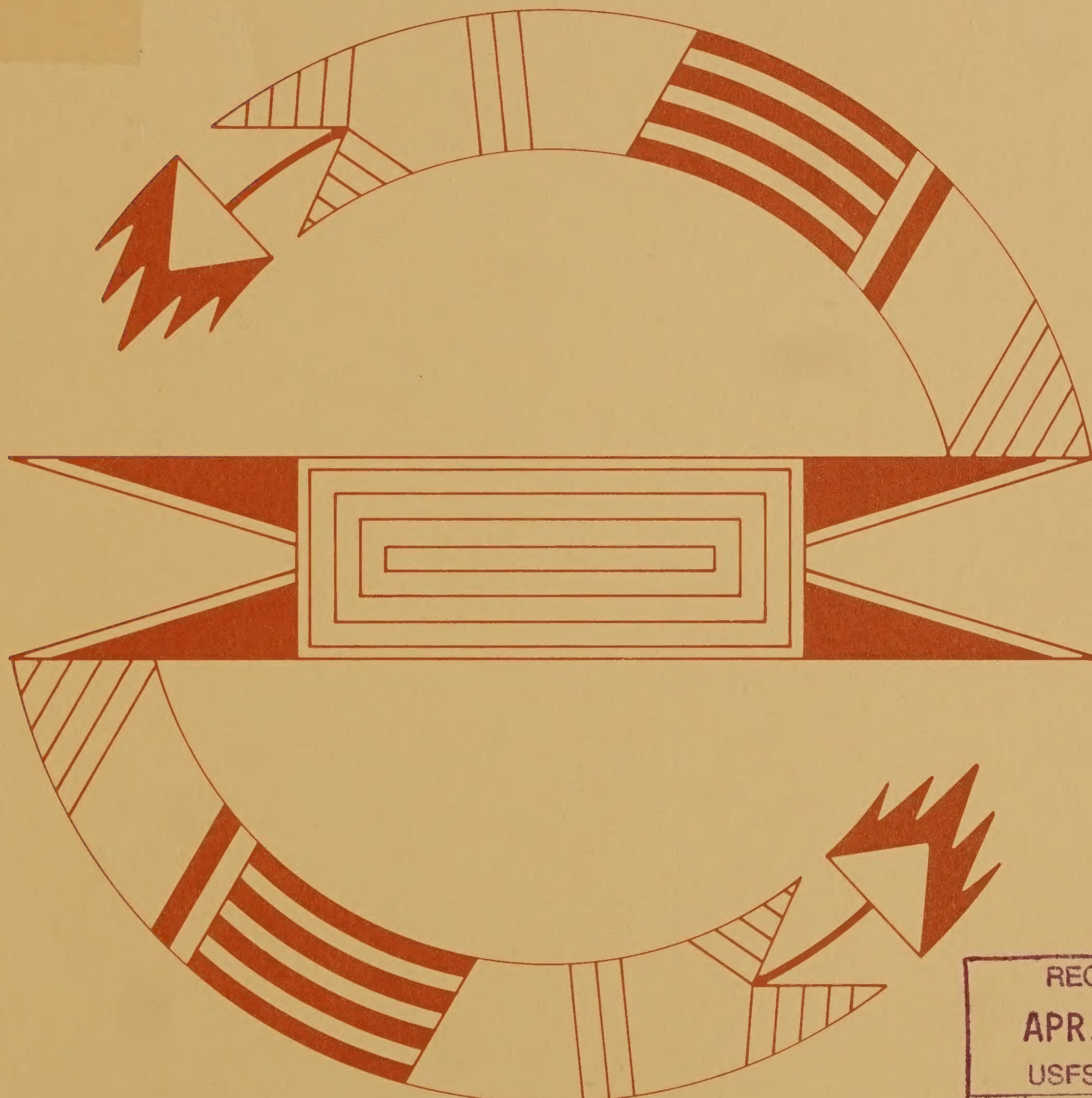
# 1978 COOPERATIVE DOUGLAS-FIR TUSSOCK MOTH NPV PILOT CONTROL PROJECT



COUNTY OF LOS ALAMOS, NEW MEXICO





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FOREST INSECT AND DISEASE MANAGEMENT • STATE AND PRIVATE FORESTRY • 517 GOLD AVE., SW • ALBUQUERQUE, NM 87102

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Los Alamos, New Mexico
1978

by

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## I. INTRODUCTION

The Douglas-fir tussock moth, Orgyia pseudotsugata McD., is a destructive defoliator of coniferous forests in western North America. This insect periodically reaches epidemic levels causing heavy defoliation with a subsequent loss in tree growth, killing or top-killing many trees, and weakening many others (Wickman et al. 1971). The tussock moth has defoliated ornamental fir and spruce trees in Los Alamos, New Mexico, since 1968 (Lessard 1975). The infestation began on ornamental spruce and white fir within the townsite, gradually spreading into the adjacent canyons.

The infestation does not appear to exhibit the 3-year cyclic outbreak pattern characteristic of populations monitored in other forest situations, e.g., in the Pacific Northwest, where outbreaks are often brought under control by epizootics of a nucleopolyhedrosis virus (Wickman et al. 1973).

In 1976, light defoliation and numerous egg masses were first observed on forested land in Los Alamos and Pueblo Canyons, which dissect the townsite area of Los Alamos. By 1977, moderate to complete defoliation occurred on 600 acres of mixed conifer type in these canyons. Despite the high tussock moth population levels, no incidence of the nucleopolyhedrosis virus (NPV) was found in 1977 or the spring of 1978 (personal communication with M. Stelzer, 1978).

In the past, infestations of this insect have been controlled through aerial applications of DDT. More recently, a microbial insecticide consisting of a baculovirus of the Douglas-fir tussock moth has shown promise as an environmentally safe control agent. Several years of field tests in other areas of the United States (Thompson 1966; Maksymiuk et al. 1968; McGregor et al. 1974; Stelzer et al. 1975) and in Canada (Stelzer et al. 1977) have demonstrated the effectiveness of this material against early stage larvae of this insect.

The outbreak in Los Alamos and Pueblo Canyons offered the opportunity to evaluate the performance of the Douglas-fir tussock moth nucleopolyhedrosis virus in the Southwest.

## II. PROJECT OBJECTIVES

The primary objective of this pilot control project was to evaluate the effectiveness of the U. S. Environmental Protection Agency-registered preparation of the Douglas-fir tussock moth virus in suppressing an outbreak population of the Douglas-fir tussock moth under operational conditions in New Mexico. In addition, data collected during the project were to be used to calibrate the "DFTM Stand Outbreak Model" developed by the Douglas-fir Tussock Moth Research and Development Program.

## III. METHODS

### A. The Treatment Area

The treatment area is located in the County of Los Alamos (Sections 9, 10, 15, 16, 17; T19N; R6E) in the Jemez Mountains of north central New Mexico (Fig. 1). The infestation in Los Alamos comprised two separate situations: forested areas in Los Alamos and Pueblo Canyons, and ornamental trees on private ownership within the city.

Los Alamos Canyon runs east-west with the treatment area covering a distance of 3.6 miles. The canyon averages 900 feet wide and 180 feet deep in the treatment area. The infestation occured mostly along the north-facing canyon wall. In Pueblo Canyon, the treatment area is divided among three canyon branches and occured primarily along the north-facing wall for a distance of 3.3 miles.

The surrounding canyon rims contained 1,900 scattered ornamental trees to be treated. These individual trees required treatment to protect adjacent forested canyon lands from reinvasion.

### B. The Pesticides

1. The pesticide applied to the infested area of Los Alamos and Pueblo Canyons was TM-Biocontrol-1, a DFTM-NPV preparation which the U. S. Environmental Protection Agency registered for use against the tussock moth in 1976. TM-Biocontrol-1 is a white powder consisting of crystalline protein bodies (polyhedra) in which mature virions (infective agents) of the Douglas-fir tussock moth nucleopolyhedrosis virus are occluded. TM-Biocontrol-1 is produced by infecting living larvae of the tussock moth and harvesting the NPV produced shortly before the insects die.

The DFTM-NPV effects are specific to the Douglas-fir tussock moth and some closely related tussock moths; no adverse effects on non-target organisms have been identified.

To make the TM-Biocontrol-1 sprayable, and to improve its effectiveness, several materials are tank-mixed and added to the product. Composition of the sprayed formulation on a per-acre basis was as follows:

| | |
|---|---|
| TM-Biocontrol-1 | $1 \times 10^9$ Activity Units |
| Molasses | 0.25 gal. |
| Shade® (a sunscreen) | 0.5 lb. |
| Water | 0.72 gal. |


Fig. 1.--Location of DFTM-NPV treatment area, 1978.


Fig. 2.--Location of untreated check area, 1978.

2. Ornamental trees in the city were treated with the Sevimol® 4 formulation of carbaryl at the rate of 1 pound actual carbaryl per 100 gallons of water sprayed to the point of runoff. The insecticide carbaryl is a broad spectrum, relatively non-persistent carbamate (Haynes et al. 1957) that has been used to suppress various insect outbreaks (Back 1965). Carbaryl is registered by the Environmental Protection Agency for use against many destructive insects.

C. Project Planning and Operations

1. Planning

Since ownership of the treatment area was divided between the Forest Service, Department of Energy, County of Los Alamos, and private individuals, the cooperation of the following groups was enlisted: Santa Fe National Forest, Department of Energy, New Mexico Department of Agriculture, Division of Forestry of the New Mexico Department of Natural Resources, and the County of Los Alamos.

Several planning sessions and two public meetings were held to coordinate the project preparation and to involve the public.

2. Personnel

Personnel from the Forest Insect and Disease Management Staff Unit, State and Private Forestry, Albuquerque, New Mexico, administered the project. Other individuals from the County of Los Alamos, Division of Forestry of the New Mexico Department of Natural Resources, New Mexico Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, and the Santa Fe National Forest worked on the project. Additional assistance was provided by the Methods Application Group, Davis, California. A chart of the project organization is shown in Table 1.

3. Aerial Application

a. Aircraft. A Hiller model UH-12E JE applied the spray mixture to the treatment area. This aircraft is a converted UH-12E with an Allison gas turbine (Model 250-(20)) rated at 400 SHP. It is owned by Ag Helicopters, Inc., Fort Collins, Colorado.

(1) Designated Operating Parameters

Aircraft Speed - 70 mph
Swath Width - 100 ft.
Boom Spray Pressure - 40 psig
Application Rate - 1 gal. per acre
Calculated Flow Rate - 14 gal. per minute

(2) Spray System

Tank - Simplex 100 gal. fiberglass
Pump - Hydraulic driven centrifugal pump with a manual valve in cockpit for pressure regulation.
Strainer - An approximately 50-mesh strainer was located between the pump and the boom.
Boom - Forty feet long, toe mounted, aluminum airfoil boom.

(3) Nozzles and Tips

Number - 37
Nozzles - Spraying Systems Tee-Jet® diaphragm check valve nozzles.
Tips - SS 8004 flat fan spray tips.
Strainers - Tee-Jet® 6051-SS strainers with 50-mesh screens were placed in each nozzle.
Orientation - 45 degrees forward and down.
Placement - Symmetrical with approximately even spacing along the boom to a point about 1-foot inboard of the rotor tip.

b. Application Rate. The NPV was applied at the rate of $1X10^9$ activity units in 1 gallon of finished spray per acre.

c. Calibration. On June 2, 1978, 100 gallons of spray formulation, less virus, was prepared. Seventy-six and one-half (76.5) gallons of the formulation was sprayed through the system in 5 minutes 26 seconds; this is equal to 14.09 gallons per minute. In addition, a piece of monitoring equipment (designed by Richard Orchard, Forestry Sciences Laboratory, Corvallis, Oregon) which measured flow rate, elapsed spray time, number of spray passes, and boom pressure was installed in the spray aircraft to check these parameters during treatment.

d. Atomization. During May 1978, the atomization produced from the Hiller aircraft was checked at Fort Collins, Colorado, using Spraying Systems Tee-Jet® 8006 flat fan nozzle tips. Because the deposit proved to be unsatisfactory, three additional atomization trial runs were made on June 2, 1978, using the spray formulation minus NPV and the nozzles and tips described in section IIIC3a(3). A card line was laid out at right angle to the wind on a mesa near the Copar pumice mine, above Rendija Canyon.

Figure 3.--Spray aircraft in Los Alamos Canyon, Los Alamos, New Mexico, 1978.

Figure 4.--NPV mixing and handling equipment, Los Alamos, New Mexico, 1978.

The helicopter was instructed to fly across the card line at 70 m.p.h. and 25 feet above the ground. Wind gusts during the first and third runs resulted in excessive skewing of droplets so that volume mean diameter (VMD) was not determined. Although there was some droplet skewing, VMD for the second run was determined and found to be 228 um; number mean diameter (NMD) was 90 um.

e. Mixing and Handling Equipment. A high speed electric stirring paddle was used to agitate a small batch of prepared tank mix in a 55-gallon drum. The virus preparation was brought into suspension by addition of the TM-Biocontrol-1 to the contents of the drum while agitation was maintained. This suspension was added to a 250-gallon slurry mixer.

A 250-gallon slurry mixer with both a mechanical paddle and recirculation for agitation was used to prepare 200-gallon batches of the spray formulation. Separate gasoline engines were used to drive the mechanical paddle and to recirculate or pump the formulation from the mixing tank. An in-line strainer with a 50-mesh screen and a Neptume Type S Green Seal Meter were used in the transfer line. Prepared formulation was transferred to one compartment of a 4,000-gallon tanker for storage before transfer to the spray aircraft.

A 4,000-gallon tanker separated into five compartments was provided by the aerial spray contractor. Four of the compartments were available for formulation use since the front compartment held aviation fuel. Two of the available compartments were utilized; one for water storage, and the other for mixing and storage of the finished spray material. Mixing in the mixing and storage compartment was accomplished by recirculation.

The pump on the tanker was plumbed to transfer to the spray aircraft or to recirculate back to the mixing tank, through a meter and an in-line filter with a 50-mesh screen, at the rate of 100 gallons per minute.

f. Formulation and Mixing. All mixing was done in 200-gallon batches. For a 200-gallon batch, each ingredient was added in the following order and amount:

(1) Water, 144 gallons (72%)
(2) Shade® (IMC 90001), 100 pounds (3%)
(3) Molasses, 50 gallons (25%)
(4) TM-Biocontrol-1, 1910 grams

The following mixing procedure was used:

(1) Metered in 144 gallons of water.

Figure 5.--High speed electric stirring paddle used to bring NPV into suspension, Los Alamos, New Mexico, 1978.

(2) While water was agitated violently, slowly (approximately 15 minutes) added 100 pounds of Shade® from four pails. Continued agitation for 30 minutes.

(3) Using a fork lift, added 50 gallons of molasses from a 55-gallon drum and mix for 5 minutes.

(4) Transferred 30 gallons of tank mix into an open 55-gallon drum. Slowly added 5,730 grams of TM-Biocontrol-1 into the 55-gallon drum while content was agitated.

(5) After thorough mixing, transferred 10 gallons of the NPV mix into the slurry mixer. This was mixed for 5 minutes, after which contents of the tanker were transferred to the large mixing tanker compartment.

(6) Steps 1, 2, 3, and 5 were repeated for the next two batches, then the total 600-gallon batch was recirculated in the tanker mixing compartment. Another 600-gallon batch was prepared using the same procedure.

g. Spray Deposit Assessment. White Kromekote® cards were used to monitor spray deposition and drift in an open area, around trees, and near Los Alamos Reservoir. Cards were placed at cardinal directions around the trees. No dye was added to the spray, since the molasses and Shade® made the drop stains sufficiently dark.

h. Weather Forecasting and Meteorological Monitoring. The meteorologist in charge of the Albuquerque Weather Forecast Office, National Weather Service, provided a daily synoptic forecast to the project meteorologist.

Weather was favorable June 3 and 4 during aerial spraying. Weather records during treatment are given in Table 2.

i. Orientation of Spray Aircraft. An Aerospatiale Lama helicopter with an aerial observer was used to direct the spray aircraft during the entire spray operation.

4. Ground Application

a. Ground Sprayers. Two 3/4-ton pickup trucks equipped with Bean hydraulic sprayers were used to apply Sevimol® 4 to individual townsite trees. Equipment is owned by Kill-A-Bug, Albuquerque, New Mexico.

Figure 6.--Application of Sevimol®-4 by high pressure sprays, Los Alamos, New Mexico, 1978.

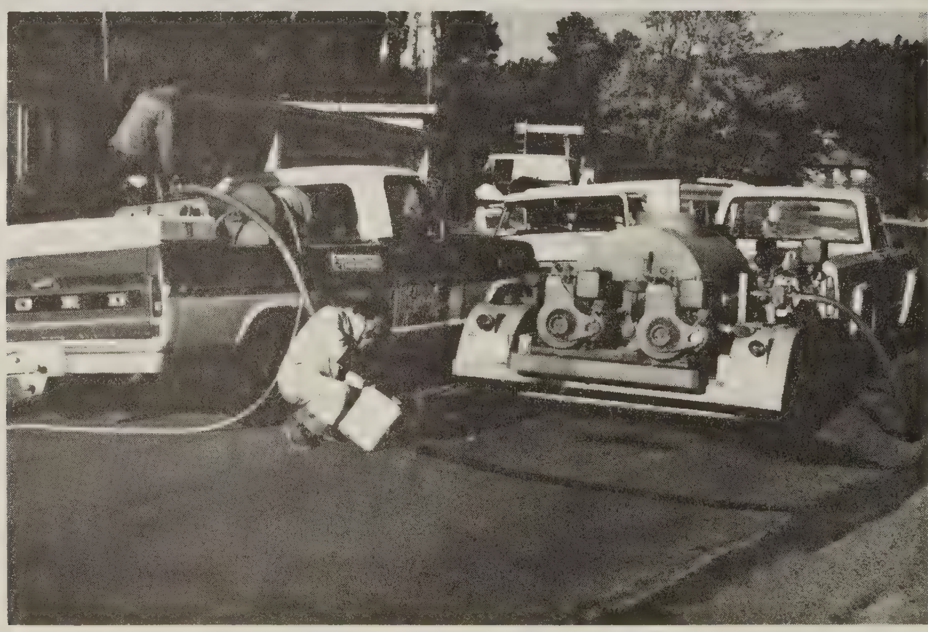

Figure 7.--Spray truck and nurse tanker, Los Alamos, New Mexico, 1978.

(1) Spray System

(a) System No. 1

Model - Bean 1010
Tank - 150 gal.
Engine - 6.5 Hp Kohler
Disc Size - #6
Pressure - 300 lbs. p.s.i.
Hose - 300 ft.

(b) System No. 2

Model - Bean 1010A
Tank - 200 gal.
Engine - 7 Hp Briggs & Straton
Disc Size - #8
Pressure - 300 lbs. p.s.i.
Hose - 300 ft.

b. Application Rate. The Sevimol ® 4 formulation of carbaryl was used at a rate of 1 pound actual carbaryl per 100 gallons of water. Trees were sprayed until the point of runoff.

c. Formulation and Mixing. A portable 250-gallon slurry mixer was used to supply water to the spray trucks. The water was metered into the tank mounted on the spray truck. The Sevimol ® 4 formulation was mixed onsite in 100- to 200-gallon batches. The formulation was agitated in the tank for 15 minutes to insure adequate mixing of the chemical.

The following mixing procedure was used:

(1) Metered water into spray tank.

(2) Added 1 quart of Sevimol ® 4 per 100 gallons of water.

(3) Agitated 15 minutes in spray tank.

d. Orientation of Ground Spray. Project personnel accompanied contract personnel to identify trees which required treatment.

D. Entomological Plan

1. Development Sampling. In New Mexico, initial egg hatch usually occurs at 220 degree-days accumulated from May 1. Degree-days were calculated as follows:

$$\frac{\text{MAX DAILY}^{\circ} + \text{MIN. DAILY}^{\circ}}{2} - 42^{\circ}\ \text{F}$$

Figure 8.--Sampling of Douglas-fir tussock moth larvae in Pueblo Canyon, Los Alamos, New Mexico, 1978.

After initial egg hatch, 100 randomly selected egg masses were examined every 2 days in the cooler canyon bottoms. Depending on weather, first instar larvae disperse to new foliage within 1 or 2 days. Treatment was to begin within 72 hours following the apparent dispersal.

2. Larval Population Sampling. Larval samples were taken with a pole pruner equipped with an attached basket. Two 18-inch (minimum) midcrown branches were pruned at each sample period from opposite sides of the tree. Branch length and width were measured and the number of DFTM larvae counted. Measurements were expressed as the number of larvae/1000 in.$^2$ foliage. Larval populations were sampled within 48 hours pretreatment and at 12 and 35 days post-treatment. The last sample was taken about 2 weeks before the onset of pupation.

Larval sampling in the canyons was done on 10 plots established in April 1978. Eight of the plots were in Los Alamos Canyon and two plots were in Pueblo Canyon. Each plot contained 10 Douglas-fir and 5 white fir. Sample trees were 30 to 50 feet in height, as open-grown as possible, and had sufficient foliage for four (2-branch) samples from midcrown.

Five control plots were selected outside the treatment area in Medio Dia Canyon. Criteria for selection of this canyon included identical outbreak history, similar ecological-entomological situation, proximity to the treatment area, and the lack of virus disease in the population. These plots were sampled simultaneously with the treatment plots.

Larval sampling for the townsite ornamental trees consisted of taking three midcrown branches (18 inches) from each of 10 trees. Trees were sampled 48 hours pre-treatment and at 7 days post-treatment.

3. Egg Mass Sampling. Trees were sampled for egg masses in May and November 1978 to determine egg mass density. The sampling scheme consisted of seven plots in Los Alamos Canyon and one plot in Pueblo Canyon. In each plot, four whole midcrown branches were sampled from each of eight trees. Virus incidence was determined by collecting 25 egg masses per plot and sending the egg masses to Clarence Thompson at the Pacific Northwest Forest and Range Experiment Station for analysis.

## IV. RESULTS

### A. Timing of Application

Pesticide application timing was based on: 1) complete egg hatch and 2) dispersal of first instar larvae from egg masses. Initial egg hatch occurred on May 15 (120 degree-days) on

the mesa tops and on May 22 (215 degree-days) in the bottom of Los Alamos Canyon. The range in date of initial egg hatch from canyon rim to bottom was due to the great difference in temperature and amount of sunlight reaching these areas.

The ground application to 1,901 ornamental trees was conducted from May 25-30, 1978. when 50 percent of the larvae had reached the second instar.

Larval samples collected on June 1, 1978, indicated 100 percent egg hatch and larval dispersal in the canyons. Larval development, canyon wide, consisted of 80 percent first and second instar, 17 percent third instar, and 3 percent fourth instar. Aerial treatment of 1,200 acres within the canyons using NPV was done on June 3 and 4, 1978.

B. Spray Assessment

Spray aircraft monitoring equipment data showing volume loaded, volume sprayed, elapsed spray time, flow rate, number of spray passes, and boom pressure range for each load are presented in Table 3. The duration of each spray pass by load is given in Table 4.

A Quantimet image analyzer was used to analyze the spray deposit cards collected. Because of halos around the droplet stains, many of the cards collected could not be analyzed accurately, and were read only for drops per square centimeter. Spray cards received an average deposit of 0.32 gallons per acre. Detailed results are shown in Table 5.

C. Population Reduction

In 1976, sampling indicated a population of fewer than five larvae per 1000 in.$^2$ of foliage in Los Alamos Canyon. Population density increased exponentially by 1977 to 64 larvae per 1000 in.$^2$ of foliage. Pre-treatment larval densities for 1978 averaged 150 larvae per 1000 in.$^2$ of foliage. Pre- and post-treatment larval densities for treatment and check areas are summarized in Table 6. Prior to treatment, there were no significant differences between treatment (150 larvae/1000 in.$^2$) and control (144 larvae/1000 in.$^2$) plots.

Larval densities were recorded for white fir and Douglas-fir; in all plots larval densities were greater on white fir. Pre-treatment densities for Douglas-fir were 134 larvae/1000 in.$^2$ for treated plots and 127 larvae/1000 in.$^2$ for control plots. The corresponding densities for white fir were 192 larvae/1000 in.$^2$ for treated plots and 200 larvae/ 1000 in.$^2$ for control plots.

Post-treatment larval sampling was done 12 and 35 days following treatment. Larval densities decreased significantly in treated areas (94.58 percent) by the 35 day post-treatment sample. Insect mortalities for the treatment area are presented in Table 7. Although larval densities decreased in the control plots from natural causes, the decrease was not sufficient in size to indicate either a declining or collapsing population.

In addition to sampling for larval density at 12 days after treatment, 50 larvae were collected from each sample cluster, placed in separate petri dishes, and maintained on artificial medium. Following an incubation period of 2 weeks, the dead larvae were sent to Dr. Martignoni at the Forestry Sciencies Laboratory in Corvallis, Oregon, for determination of virus incidence. Examination of these larvae indicated an excellent NPV infection rate, ranging from 63.6 percent to 96.2 percent and averaging 81.5 percent (Stelzer personal communication 1978).

An egg mass survey consisting of eight sample plots with eight trees per plot and four whole midcrown branches per tree detected no new egg masses in the NPV treatment area.

Larval population sampling will be conducted in the spring of 1979 to further define the impact of the NPV treatment in Los Alamos and Pueblo Canyon.

Post-treatment larval sampling of the Sevimol® 4 treated ornamental trees showed 98.5 percent larval mortality.

## D. DFTM Stand Outbreak Model

To provide data which could be used to help in calibration of the DFTM Stand Outbreak Model, larval sample plots (clusters) were established in a manner such that data from each individual cluster could provide independent input to the model. Data for pre- and post-spray larval densities on Douglas-fir and white fir in each cluster in the treatment and check areas are summarized in Tables 8 and 9 and 10 and 11, respectively.

Stand outbreak model parametric estimates of 35 day post-treatment larval populations were generated using pre-treatment larval population counts; a comparison of model estimates with field sampling results is given in Table 12.

## E. Operational Problems

Several problems were encountered during the formulation process and in spraying. The first difficulty appeared while adding Shade® in mixing a 100-gallon batch of formulation less the NPV. The small volume prevented use of the stirring paddle, and

mixing was conducted by recirculation only. Insufficient wetting of the Shade® took place as it was slowly poured into the mixing tank, and severe caking and clumping as well as strainer plugging occurred. Approximately 2 hours were required to mix this first batch. In subsequent batches, where larger volumes were prepared using the mechanical paddle agitator, no clumping or caking was observed. This method still required a good deal of time because Shade® must be added slowly to achieve the required wetting.

The second problem arose when, after spraying 560 gallons, the in-line strainer of the helicopter plugged severely enough to reduce flow. Thereafter, it had to be cleaned on alternate loads. When the in-line strainer was subsequently removed, the screens at the nozzles plugged. The particles causing the plugging have not been identified, but have indirectly been traced to the molasses. These same crystalline particles were observed in spray drops on cards from a Ft. Collins atomization test where only water, dye, and molasses (from a source different from that obtained for the project) were used.

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## ACKNOWLEDGMENTS

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APPENDIX

Table 1

Organization Chart
Los Alamos NPV Pilot Project, 1978

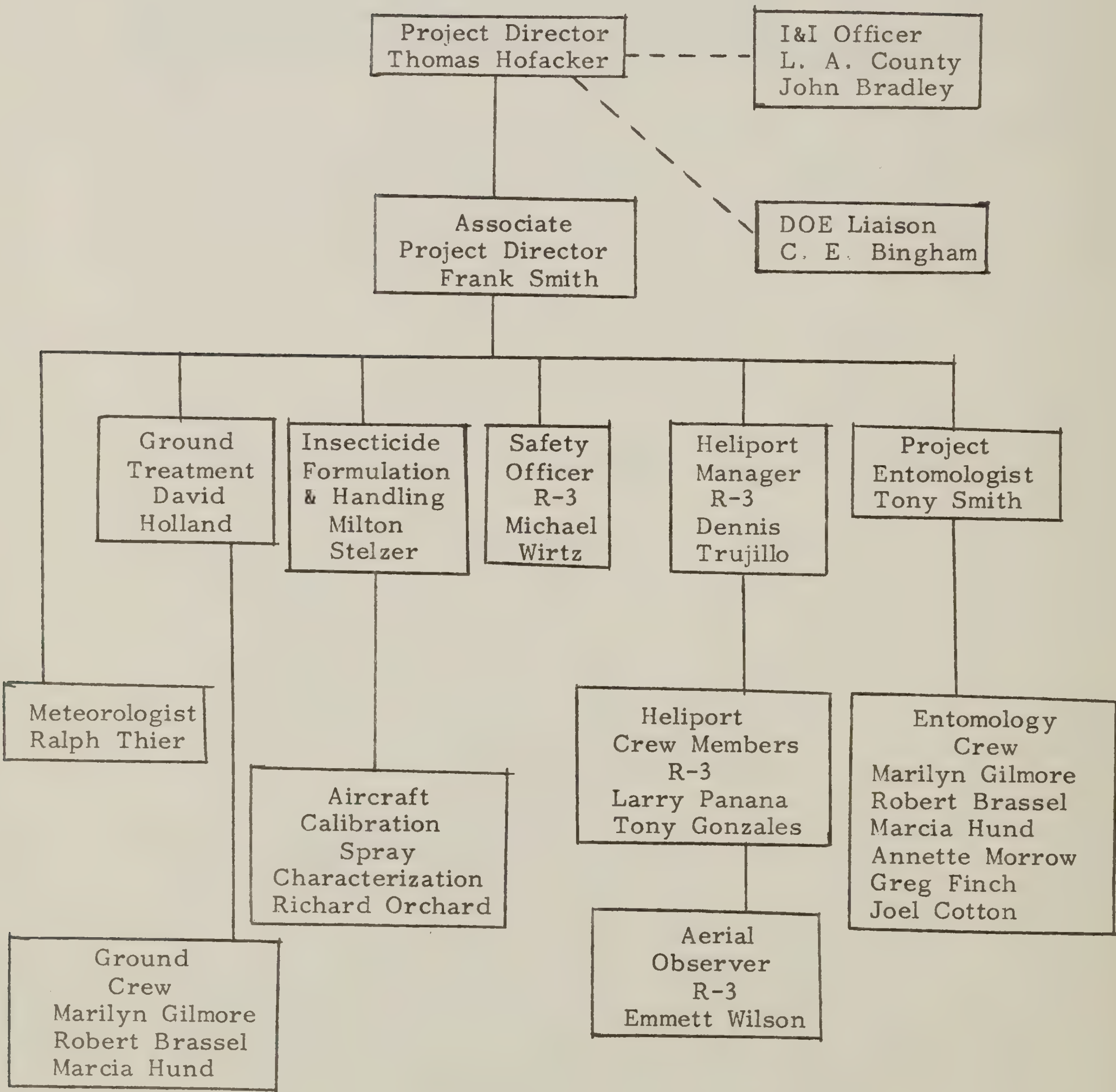

Table 2.--Weather records during treatment. Los Alamos NPV Pilot Project, 1978.

| Date | Area Treated | Time | Temperature (Degrees F) | Relative Humidity | Wind Speed |
|---|---|---|---|---|---|
| 6/3 | Pueblo | 5:27 | 45 | 72 | 1 |
| | Canyon | 6:26 | 41 | 88 | 1 |
| | | 7:00 | 46 | 86 | 2 |
| | | 7:21 | 52 | 72 | 4 |
| | | 8:15 | 56 | 61 | 2 |
| | Los | 9:15 | 61 | 54 | 2 |
| | Alamos | 10:07 | 61 | 54 | 2 |
| 6/4 | Canyon | 5:50 | 47 | 66 | 2 |
| | | 6:08 | 44 | 69 | 2 |
| | | 6:30 | 46 | 64 | 2 |
| | | 6:50 | 41 | 100 | 2 |

Table 3.--NPV Spray Load and Monitoring Equipment Data Los Alamos NPV Pilot Project, 1978.

6-3-1978

| Load No. | Volume in (gal) | Volume Sprayed (gal) | Elapsed Spray time (min) | Flow rate gal. sprayed/time (gpm) | No. of spray passes | boom pressure range (psi) |
|---|---|---|---|---|---|---|
| 1 | 80 | 77.6 | 6.13 | 12.7 | 8 | 29-41 |
| 2 | 80 | 80.7 | 6.30 | 12.8 | 9 | 37-43 |
| 3 | 80 | 81.4 | 6.63 | 12.3 | 7 | 33-42 |
| 4 | 80 | 78.7 | 5.83 | 13.5 | 14 | 40-48 |
| 5 | 80 | 80.8 | 6.27 | 12.9 | 7 | 38-46 |
| 6 | 80 | 80.6 | 6.00 | 13.4 | 9 | 38-49 |
| 7 | 80 | 79.9 | 5.83 | 13.7 | 5 | 40-48 |
| 8 | 80.4 | 30.0 1/ | --- | --- | 5 | 15-40 |
| 9 | 30 2/ | 54.2 | 4.30 | 12.6 | 4 | 15-48 |
| 10 | 60.1 3/ | 59.9 | 4.47 | 13.4 | 4 | 50-53 |
| 11 | 63.1 | 59.0 | 5.63 | 10.5 4/ | 10 | 15-58 |
| 12 | 60.1 | 62.0 | --- | --- | 3 | 43-50 |
| 13 | 60.1 | 59.8 | 6.30 | 9.5 5/ | 5 | 37-46 |
| Total | 913.8 | 884.6 6/ | | | | |

6-4-78 7/

| Load No. | Volume in (gal) | Volume Sprayed (gal) | Elapsed Spray time (min) | Flow rate gal. sprayed/time (gpm) | No. of spray passes | boom pressure range (psi) |
|---|---|---|---|---|---|---|
| 1 | 60 | 54.9 | 4.63 | 11.9 | 3 | 32-38 |
| 2 | 71.3 | 71.2 | 5.17 | 13.8 | 4 | 40-49 |
| 3 | 70.1 | 40.6 8/ | 3.30 | 12.3 | 12 | 16-46 |
| 4 | 60.2 | 53.7 9/ | 3.77 | 14.2 | 4 | 16-56 |
| 5 | 7 | 1.6 10/ | 0.13 | 12.3 | 1 | 16-46 |
| Total | 268.6 | 222.0 | | | | |

1/ When boom pressure dropped the pilot thought he was empty and returned after only spraying 30 gal.--cause, in-line strainer plugged.

2/ Added 30 gal. to make a total of 80.

3/ Added 60.1 to make a total of 86.

4/ Boom pressure dropped, reducing the flow rate. Cause--in-line strainer was plugged. Removed screen from strainer for the 12th and 13th load.

5/ Screens at nozzle tips were plugged, reducing the flow rate.

6/ The discrepancy between total volume in and total volume sprayed is because some was sprayed at less than 15 lb. boom pressure, in which case the total flow and elapsed spray time will not record.

7/ Cleaned in-line strainer and either cleaned or replaced all nozzle screens prior to this day's spraying.

8/ Returned with about 15 gal. - sprayed some at less than 15 psi boom pressure--in-line strainer partially plugged.

9/ Developed leak in hose connecting cross-over tube - lost about 22 gal. due to leak.

10/ Lost about 5.4 gal. due to same leak as in load no. 4.

Table 4. Duration (min.) of each aircraft spray pass by load Los Alamos NPV Pilot Project, 1978.

| | 6-3-78 Spray day | | | | | | | | | | | | | 6-4-78 Spray day | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Load No. / Pass No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 1 | 2 | 3 | 4 | 5 |
| 1 | 1.5 | 0.6 | 1.1 | 0.5 | 1.0 | 0.5 | 1.1 | 1.3 | 1.1 | 1.2 | 0.1 | 1.9 | .04 | 1.6 | 1.8 | 0.7 | 1.8 | 0.1 |
| 2 | 1.4 | 0.3 | 0.3 | 0.4 | 1.0 | 0.5 | 0.8 | 1.2 | 1.2 | 1.2 | 0.1 | 2.0 | 1.5 | 1.3 | 1.3 | 1.0 | 1.3 | |
| 3 | 0.7 | 0.4 | 0.8 | 0.5 | 0.9 | 0.4 | 1.1 | 0.6 | 1.3 | 1.2 | 2.0 | 1.6 | 1.9 | 1.7 | 1.7 | 1.6 | 0.4 | |
| 4 | 0.5 | 0.3 | 1.4 | 0.4 | 0.9 | 0.4 | 0.9 | 0.8 | 0.6 | 1.0 | 1.9 | | 1.7 | | 0.4 | 1.0 | 0.3 | |
| 5 | 0.8 | 1.0 | 1.5 | 0.4 | 0.9 | 0.4 | 1.9 | 0.6 | | | 0.4 | | 1.1 | | | 1.2 | | |
| 6 | 0.7 | 0.3 | 1.3 | 0.4 | 0.8 | 1.5 | | | | | 0.3 | | | | | 0.2 | | |
| 7 | 0.5 | 0.7 | 0.2 | 0.4 | 0.8 | 1.1 | | | | | 0.3 | | | | | 0.2 | | |
| 8 | 0.1 | 1.4 | | 0.3 | | 1.0 | | | | | 0.3 | | | | | 0.1 | | |
| 9 | | 1.4 | | 0.3 | | 0.3 | | | | | 0.1 | | | | | 0.1 | | |
| 10 | | | | 0.3 | | | | | | | 0.1 | | | | | 0.1 | | |
| 11 | | | | 0.3 | | | | | | | | | | | | 0.1 | | |
| 12 | | | | 0.3 | | | | | | | | | | | | 0.1 | | |
| 13 | | | | 0.4 | | | | | | | | | | | | | | |
| 14 | | | | 1.0 | | | | | | | | | | | | | | |

Table 5.--NPV spray deposit data. Los Alamos NPV Pilot Project, 1978.

| Location | Number Observations | VMD 1/ | GPA 2/ | Avg. drops/ $cm^2$ 3/ |
|---|---|---|---|---|
| Treatment Area | 201 | 363 | 0.32 | |
| | 340 | | | 10.03 |
| Open Area | 9 | | | 10.88 |
| Reservoir | 4 | | 0.00 | 0.00 |

1/ Volume mean diameter of spray droplets.

2/ Gallons per acre of deposit.

3/ Average drops per square centimeter deposited on center of spray cards.

Table 6.--Pre-spray and post-spray larval densities on treated and control plots - Los Alamos NPV Pilot Project, 1978.

Los Alamos and Pueblo Canyons

| Treatment Sample Plots | Pre-spray Larval Density* | Post-spray 12 Days | Post-spray 35 Days |
|---|---|---|---|
| 1 | 10.09 | 2.14 | 0.08 |
| 2 | 12.82 | 9.14 | 2.46 |
| 3 | 33.55 | 12.43 | 5.31 |
| 4 | 155.70 | 98.92 | 15.39 |
| 5 | 304.67 | 231.03 | 17.05 |
| 6 | 609.98 | 248.05 | 7.16 |
| 7 | 110.20 | 58.06 | 9.99 |
| 8 | 34.84 | 14.58 | 4.43 |
| 9 | 102.79 | 74.59 | 8.18 |
| 10 | 124.33 | 94.19 | 10.56 |
| x | 149.90 | 84.13 | 8.12 |

Medio Dia Canyon

| Control Sample Plots | Pre-spray Larval Density | Post-spray 12 Days | Post-spray 35 Days |
|---|---|---|---|
| **1 | 6.45 | 1.06 | --- |
| 2 | 78.18 | 49.28 | 30.82 |
| 3 | 108.15 | 72.26 | 62.65 |
| 4 | 173.95 | 81.81 | 96.44 |
| 5 | 215.70 | 163.31 | 99.07 |
| x | 144.00 | 91.67 | 72.25 |

* Number of larvae/1000 in.$^2$ foliage.
** Plot discontinued because of low numbers.

Table 7: Insect mortalities for treatment area by analysis method, Los Alamos, NPV Pilot Project, 1978.

| Tree Species | 35-Day Post-Treatment Method | |
|---|---|---|
| | Unadjusted | Abbott's Formula[1/] |
| Douglas-fir | 94.92% | 92.29% |
| White fir | 93.30% | 78.87% |
| Douglas-fir & White fir | 94.58% | 89.20% |

1/ Corrected using Abbott's formula.

$$Y = 1 - \frac{(TAA \times CAB)}{(TAB \times CAA)} 100$$

where:

Y = percent control, TAB = pre-spray population treatment mean, TAA = post-spray population treatment mean, CAB = pre-spray population control mean, and CAA = post-spray population control mean.

Table 8. Insect population density for DF in Los Alamos and Pueblo Canyons.

| Cluster | Pre-spray | | Larvae Per 1000 Square Inch: 1st Post-Spray (12 Days) | | 2nd Post-Spray (35 Days) | |
|---|---|---|---|---|---|---|
| | Mean | S.E. | Mean | S.E. | Mean | S.E. |
| 1 | 9.32 | 1.87 | 1.75 | 0.66 | 0.84 | 0.58 |
| 2 | 12.46 | 5.23 | 6.95 | 2.98 | 2.91 | 0.93 |
| 3 | 32.40 | 9.15 | 7.16 | 1.66 | 2.85 | 1.15 |
| 4 | 151.15 | 24.01 | 95.59 | 26.91 | 13.88 | 3.11 |
| 5 | 319.23 | 34.82 | 259.27 | 49.20 | 13.94 | 2.84 |
| 6 | 472.10 | 92.10 | 227.79 | 23.03 | 4.24 | 1.32 |
| 7 | 85.80 | 14.08 | 44.72 | 8.73 | 4.71 | 1.03 |
| 8 | 20.79 | 5.59 | 12.95 | 2.99 | 1.61 | 0.58 |
| 9 | 78.78 | 13.96 | 51.83 | 6.30 | 9.66 | 2.85 |
| 10 | 125.09 | 25.30 | 87.75 | 24.07 | 11.80 | 4.56 |
| Average | 130.71 | 17.72 | 79.58 | 10.88 | 6.64 | 0.85 |

Table 9. Insect population density for WF in Los Alamos and Pueblo Canyons.

| Cluster | Pre-Spray | | Larvae Per 1000 Square Inch 1st Post-Spray (12 Days) | | 2nd Post-Spray (35 Days) | |
|---|---|---|---|---|---|---|
| | Mean | S.E. | Mean | S.E. | Mean | S.E. |
| 1 | 11.57 | 3.23 | 2.57 | 1.67 | 0.54 | 0.54 |
| 2 | 14.17 | 4.04 | 12.26 | 6.21 | 2.45 | 0.14 |
| 3 | 40.17 | 22.13 | 25.25 | 13.13 | 9.07 | 5.14 |
| 4 | 171.49 | 76.69 | 162.01 | 62.74 | 18.08 | 7.75 |
| 5 | 279.23 | 82.20 | 162.25 | 61.80 | 29.08 | 11.19 |
| 6 | 965.04 | 79.80 | 298.64 | 64.54 | 16.78 | 6.57 |
| 7 | 201.64 | 90/80 | 108.49 | 23.35 | 11.15 | 7.06 |
| 8 | 81.80 | 31.19 | 21.45 | 3.30 | 12.68 | 5.84 |
| 9 | 155.48 | 53.72 | 124.42 | 30.98 | 6.50 | 0.75 |
| 10 | 137.47 | 21.03 | 123.95 | 30.37 | 9.47 | 4.81 |
| Average | 192.19 | 40.24 | 104.13 | 16.63 | 12.87 | 2.23 |

Table 10: Population density for check plots (DF) in Medio Dia Canyon.

| | Larvae Per 1000 Square Inch | | | | | |
|---|---|---|---|---|---|---|
| | Pre-Spray | | 1st Post-Spray (12 Days) | | 2nd Post-Spray (35 Days) | |
| Cluster | Mean | S.E. | Mean | S.E. | Mean | S.E. |
| 1 | | | | | | |
| 2 | 64.05 | 7.07 | 46.68 | 10.04 | 31.80 | 5.29 |
| 3 | 107.61 | 18.47 | 66.17 | 12.68 | 65.06 | 9.98 |
| 4 | 169.67 | 18.64 | 94.08 | 15.84 | 120.81 | 19.79 |
| 5 | 165.29 | 29.49 | 138.03 | 29.24 | 116.24 | 30.53 |
| Average | 126.65 | 11.90 | 86.24 | 10.44 | 83.48 | 10.90 |

Table 11: Population density for check plots (WF) in Medio Dia Canyon.

| | Larvae Per 1000 Square Inch | | | | | |
|---|---|---|---|---|---|---|
| | Pre-Spray | | 1st Post-Spray (12 Days) | | 2nd Post-Spray (35 Days) | |
| Cluster | Mean | S.E. | Mean | S.E. | Mean | S.E. |
| 1 | | | | | | |
| 2 | 115.48 | 30.70 | 61.80 | 12.40 | 39.58 | 9.44 |
| 3 | 146.57 | 80.39 | 107.26 | 38.47 | 65.09 | 25.16 |
| 4 | 196.77 | 24.40 | 38.60 | 11.30 | 52.97 | 8.42 |
| 5 | 342.83 | 40.03 | 213.73 | 38.51 | 96.61 | 9.83 |
| Average | 200.41 | 30.09 | 105.35 | 20.22 | 63.56 | 8.38 |

Table 12: Comparison of insect population between field data and stand outbreak model parametric estimates for DF and WF at 35 days post-spray for treatment blocks and check blocks.

| Category | Host | Model Phase | Clusters | Larvae Per 1000 Square Inch | |
|---|---|---|---|---|---|
| | | | | Observed | Parametric Estimates |
| Treated Blocks | DF | 2 | 1, 2, 3, 4, 9, 10 | 6.99 | 5.38 |
| | | 3 | 5, 6, 7, 8 | 6.12 | 3.43 |
| | WF | 2 | 1, 2, 3, 4, 9, 10 | 7.68 | 10.97 |
| | | 3 | 5, 6, 7, 8 | 17.42 | 24.19 |
| Check Blocks | DF | 2 | 2, 3, 4 | 72.56 | 55.82 |
| | | 3 | 5 | 116.24 | 64.68 |
| | WF | 2 | 2, 3, 4 | 52.55 | 75.03 |
| | | 3 | 5 | 96.61 | 134.14 |
| Average DF/WF | | --- | --- | 47.02 | 46.70 |

## Forest Pest Control Publications

Pesticides used improperly can be injurious to man, animals, and plants. Follow directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.